Hospital Accessibility in northern parts of British Columbia

What's the average travel time to the nearest hospital in northern parts of British Columbia?

1. Introduction

British Columbia is the third largest province in Canada by population with 13.6% of the province's population living in northern rural areas (Jeudy, 2022). Geographic location plays a huge role in access to healthcare and many of the residents in northern areas of British Columbia have a tough time accessing healthcare services due to reachability by means of transportation. To start one of the articles looked at spatial access to specialized palliative care services using GIS the results of the article show how although the majority of British Columbia's population has good access to specialized palliative centers when looking deeper into northern/rural parts of British Columbia greatly suffer with them having very scarce spatial access to specialized palliative care (Cinnamon et al., 2008). Next, another article discussed and looked at how northern/rural areas don't have proper access to healthcare services due to accessibility and geographic barriers. Healthcare in rural and remote areas is very different from urban areas and the article discusses how geography, population distribution and many other factors need to be looked at when specifically planning healthcare sights in rural areas because many barriers arise such as mountains and large bodies of water (Schuurman, 2006). Lastly, an article also examined inter-facility medical transport journey times in southeastern British Columbia and looked at if there is sufficient inter-facility transportation for people located in northern/rural areas and is trying to improve health-care service delivery. One of the results the article discussed was how elevation and mountain driving affected travel times to facilities which northern British Columbia is comprised of a lot (Buhler, 2016). So therefore, in conclusion its evident British Columbia's northern population has a lot of trouble getting access to adequate healthcare

but just how much is due to travel time to hospitals, there is still a gap in the articles with none looking at travel times to hospitals in Northern British Columbia in-depth although one article looks at travel times it was not as in-depth which is why there's a need to look at average travel time to the nearest hospital in northern parts of British Columbia.

2. Research question

What's the average travel time to the nearest hospital in northern parts of British Columbia?

3. Sample population

The sample population that will be included in my project will be specifically the population of people that live in the northern communities of British Columbia defined by the northern authority's boundary. The northern population of British Columbia will be looked at to see how they are being affected in terms of driving time to the nearest hospitals. The northern population is biased from the general population in the sense the population is mostly lower income with less access to transportation. The main social determents of health determined by the Government of Canada that will be focused on in this study are "physical environments" and "access to health services". These two determinants are the focus as northern British Columbia is a mainly rural area and is known to have very rough terrain hence looking at their "physical environments"; northern areas are also known to have inadequate access to healthcare which is why "access to health

services" is also looked at. In this study, the population in the northern communities of British Columbia is looked at nothing specific like gender or any other type of factor.

4. Data

1. Transportation Stops (TRS): This dataset shows transportation stops (rail, bus and subway stops) across Canada which will be narrowed down to northern British Columbia. This data will help show transportation access in northern parts of British Columbia which will help in turn with determining accessibility to hospitals. The distance from hospitals to transportation stops in northern British Columbia can be used to determine time it takes to get to hospitals. The is secondary data, specifically from the attribute table "CODE" will be used which represents the different types of stops across the British Columbia region. This data is quantitative and is discrete nominal integer data (Transportation Stops (TRS), n.d.).
2. Health Authorities Boundaries: This dataset contains all the different health boundaries in British Columbia. This is useful for my research question as I will be specifically looking at the northern health boundary, which is predominately rural covering northern British Columbia and with this layer I'll be able to clip all my other data within the boundary. This data is secondary data (MOH Analytics, 2018).
3. Healthcare (HCR): This dataset shows all the health care centers in British Columbia but will be modified to get the location of all the hospitals in northern British Columbia only. This helps with my research question as I can calculate driving times because I will now know the location of the hospitals. The field I will use is "NAME" to help extract

everything that is a hospital. This data is secondary qualitative nominal discrete data (Healthcare (HCR), n.d.).

4. Route File (RTE): This dataset contains all the roads in Canada. This will be helpful in my research question as it classifies the different kind of roads. The field I will use is "CARTO" which gives the classification of roads it is and nominal discrete integers.
5. Network Data Set: This dataset contains all the roads in Canada. This will be helpful in my research question as I can run build network which will help calculate the average travel time to hospitals using this layer and the hospitals points. (Network Data Set, n.d.).
6. Community Health Service Areas (CHSA): This dataset contains community level health service boundaries which will be useful as they will be converted to points and used as the starting points to hospital for average travel time. This data is secondary data (MOH Analytics, 2019).

Datasets 1,3 4 and 5 can only be accessed with a licence and are not open source by Scholars Geoportal, the data is licensed through the University of Toronto. Dataset 2 and 6 are open source from British Columbia's open data catalogue. The data types of my datasets are vectors and points, and the geospatial file types are .dbf, .htm, .lyr, .prj, .sbn, .sbx., .sbh, and .shx.

5. Analytical Methods

To start off first I will download all my data and organize it into folders named accordingly to what the folder contains, Next, I will import all my shp files and import their symbology with their lyr layers provided using the "apply symbology from layer tool". Next, I will use the

“extract by attributes tool” on the Health Authorities Boundaries file to get only the Northern boundaries polygon. After getting this polygon I will start clipping all my data to the northern boundary’s extent using the “clip tool”. Lastly, I will need to use the “select by attributes tool” on the health care layer to extract only the hospitals from the layer as it displays other healthcare services as well. Now I have all my data set up to run analysis on. The analysis I will be running on my data will be the closest facilities analysis to get travel time using the network data set, hospital points file, and community health boundary points file. To calculate average travel time, I used a network dataset layer and ran the “build network tool” on it. After build network I ran the “Make Closest Facility Analysist Layer tool”. Now I added in the clipped hospital layer as facilities and clipped community health boundary points as incidents and ran the calculation which gave me routes and average travel time from each health community to the nearest hospital to answer my research question. I choose these methods because I have previously learned them from other classes and from this classes’ labs. Other similar research questions also follow similar ways of organizing data. One of the articles that looked at hospital catchments for non-urban areas based on travel time carried out similar methods. The article also used a road network file that was different from mine known as the "Road Atlas of BC" and instead of community health boundary points the article used census data. The article built a road network dataset using data management tools. One main thing that stood out from the article’s methods and mine was that it used “create new service area tool” for its average travel time whereas I used “Make Closest Facility Analysist Layer tool” (Schuurman, 2006).

6. Results

When carrying out my results using the various geospatial tools, I realized just how big the Northern health boundary of British Columbia is. When clipping roads, transport stops and health care center layers to the boundary of the northern layer, it can be seen how few transport stops and major roads the northern part of British Columbia area has. Next going forward only extracting the hospitals for the boundary shows the hospitals compared to the size of area are very inadequate and scarce especially when looking at other regions and the number of hospitals they have. Finally, when looking at the travel time from the community health boundary points to hospitals it can be seen there's a lot of variation with some hospital's travel time only taking a few minutes while others take 30 minutes to an hour plus.

7. Appendix

Table 1:

Health Boundary	Number of Hospitals	Population (2016)	Area of Region (Km^2)	Hospital per Km^2	Population per Km^2
Interior	61	739989	215413.45	3531.35	3.43
Fraser	42	1720066	15762.26	375.29	109.12
Vancouver Coastal	42	1131705	55091.06	1311.69	20.54
Vancouver Island	41	776410	55953.73	1364.72	13.87
Northern	39	279885	605576.02	15527.59	0.46

The table shows just how spread out the hospitals and population are for the Northern British Columbia Boundary and how it has the least hospitals as well.

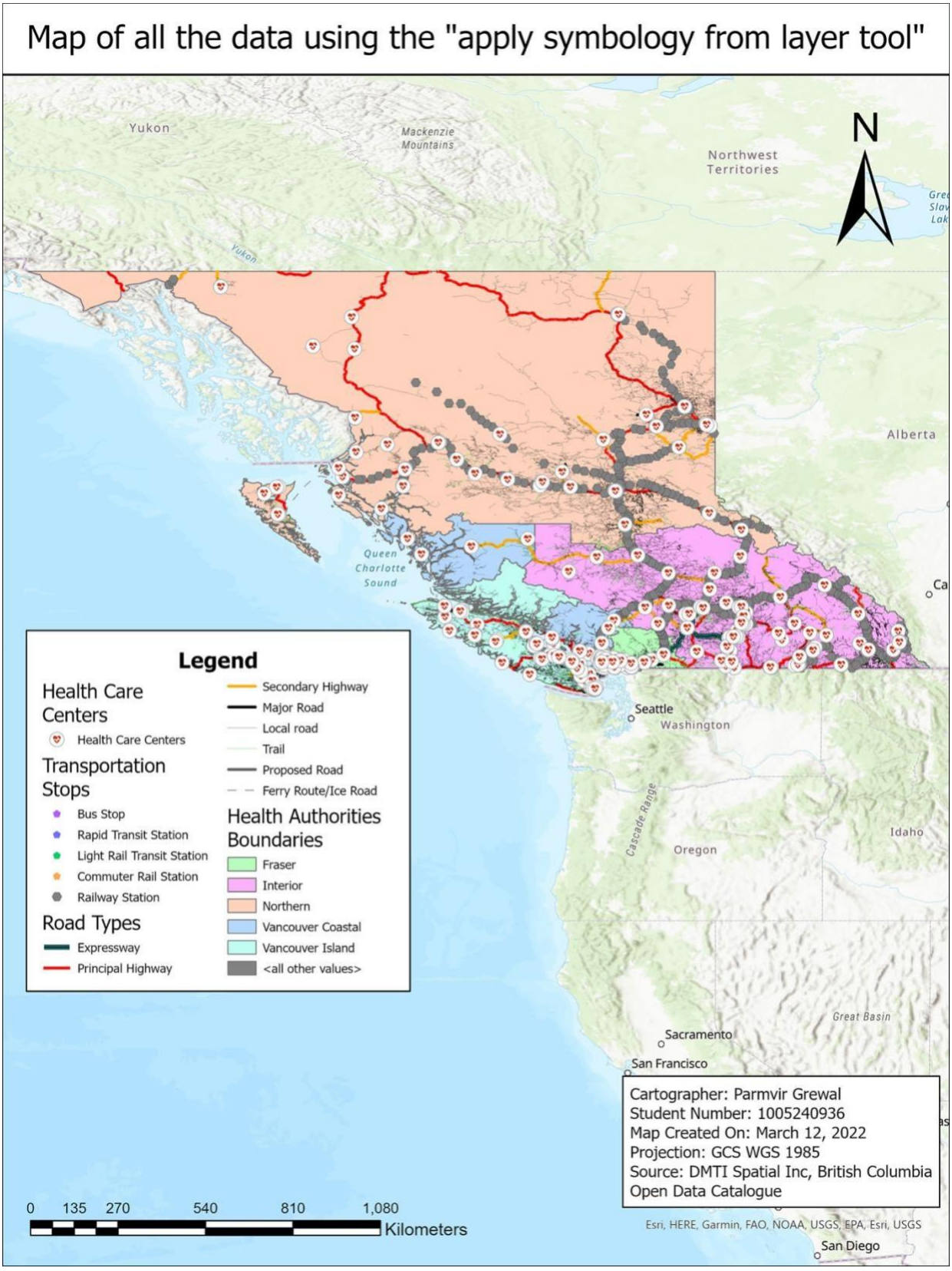
Table 2:

Name	Travel Time (Minutes)	Total Distance (Meters)
Prince Rupert City Centre - PRINCE RUPERT REGIONAL HOSPITAL	9.91437714	10906.9518

Prince Rupert Rural - PRINCE RUPERT REGIONAL HOSPITAL	32.1996341	40747.0349
Upper Skeena - WRINCH MEMORIAL HOSPITAL	9.07340036	10585.6333
Smithers Town Centre - BULKLEY VALLEY DISTRICT HOSPITAL	5.98593821	6413.22372
Smithers Rural - BULKLEY LODGE	10.6947268	10721.5418
Terrace City Centre - TERRACEVIEW LODGE	4.09310256	3410.91866
Terrace Rural - TERRACEVIEW LODGE	40.5396257	46124.6779
Nisga'a - NISGA’A VALLEY HEALTH CENTRE	19.7857843	23083.4145
Telegraph Creek - ISKUT NURSING STATION	83.7364218	105365.194
Quesnel City Centre - DUNROVIN PARK LODGE	3.22949193	2995.12714
Quesnel Rural - DUNROVIN PARK LODGE	30.3259936	33601.5694
Burns Lake Town Centre - THE PINES	1.07172109	928.536176
Vanderhoof - OMINECA LODGE	1.4245725	1187.14372
Vanderhoof Rural - OMINECA LODGE	28.8668107	34101.4893
Fraser Lake - FRASER LAKE DIAGNOSTIC AND TREATMENT CENTRE	44.4137662	52138.4588
Prince George City - North - PARKSIDE INTERMEDIATE CARE HOME	6.42636208	7214.61535
Prince George City - Central - AIMHI-PRINCE GEORGE ASSOC. FOR COMMUNITY LIVING - ADULT RESIDENCES	2.60899685	2633.88034
Prince George City - Southwest - THE UNIVERSITY HOSPITAL OF NORTHERN BRITISH COLUMBIA	9.17987165	9474.16814
Prince George Southwest Rural - THE UNIVERSITY HOSPITAL OF NORTHERN BRITISH COLUMBIA	36.7866077	40600.8651
Prince George North Fraser Rural - AIMHI-PRINCE GEORGE ASSOC. FOR COMMUNITY LIVING - ADULT RESIDENCES	100.137103	118389.652
McBride/Valemount - MCBRIDE AND DISTRICT HOSPITAL	29.4576343	39079.6373
Dawson Creek - PEACE LIARD COMMUNITY HEALTH SERVICES SOCIETY	2.17319247	1902.75483
Chetwynd - CHETWYND GENERAL HOSPITAL	1.54089509	1637.30148
Tumbler Ridge - TUMBLER RIDGE HEALTH CARE CENTRE	28.438783	33294.5162
Fort St John - FORT ST JOHN GENERAL HOSPITAL	0.78604863	655.04049
Hudson's Hope - HUDSON’S HOPE GETHING DIAGNOSTIC AND TREATMENT CENTRE	5.04934777	6732.46361
Peace River North Rural - FORT ST JOHN GENERAL HOSPITAL	122.606604	162235.646
Fort Nelson Population Centre - FORT NELSON GENERAL HOSPITAL	0.66086655	550.722081

The table shows average travel time in minutes to nearest hospitals from different health community boundary points and total distance in meters from the table it can be seen how some hospitals take a lot of time to get to and are far away.

Map 1:


Map of all the data using the "apply symbology from layer tool"
Yukon
Mackenzie Mountains
Northwest Territories
N
Alberta
Queen Charlotte Sound
Seattle
Washington
Cascade Range
Oregon
Idaho
Great Basin
Sacramento
San Francisco
San Diego
Legend
Health Care Centers
Health Care Centers
Transportation Stops
Bus Stop
Rapid Transit Station
Light Rail Transit Station
Commuter Rail Station
Railway Station
Road Types
Expressway
Principal Highway
Secondary Highway
Major Road
Local road
Trail
Proposed Road
Ferry Route/Ice Road
Health Authorities Boundaries
Fraser
Interior
Northern
Vancouver Coastal
Vancouver Island
<all other values>
0 135 270 540 810 1,080
Kilometers
Cartographer: Parmvir Grewal
Student Number: 1005240936
Map Created On: March 12, 2022
Projection: GCS WGS 1985
Source: DMTI Spatial Inc, British Columbia Open Data Catalogue
Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, Esri, USGS

Map 2:


Map of all the data using the "clip tool" for Northern British Columbia
Mackenzie
N
Great Bear Lake
Yukon
Mackenzie Mountains
Northwest Territories
Yukon
Legend
Health Authorities Boundaries
Northern Health Care Boundary
Transportation Stops
Railway Station
Road Types
Expressway
Principal Highway
Secondary Highway
Major Road
Local road
Trail
Proposed Road
Ferry Route/Ice Road
Health Care Centers
Health Care Centers
Queen Charlotte Sound
Seattle
Washington
Portland
Cartographer: Parmvir Grewal
Student Number: 1005240936
Map Created On: March 12, 2022
Projection: GCS WGS 1985
Source: DMTI Spatial Inc, British Columbia Open Data Catalogue
0 112.5 225 450 675 900
Kilometers
Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, NRCan, Parks Canada, Esri, USGS

Map 3:


Map of all the data using the "select by attributes tool" to show only hospitals
Mackenzie
N
Great Bear Lake
Yukon
Mackenzie Mountains
Northwest Territories
Yukon
Queen Charlotte Sound
Seattle
Washington
Portland
Legend
Health Authorities Boundaries
Northern Health Care Boundary
Transportation Stops
Railway Station
Road Types
Expressway
Principal Highway
Secondary Highway
Major Road
Local road
Trail
Proposed Road
Ferry Route/Ice Road
Health Care Centers
Hospitals
Cartographer: Parmvir Grewal
Student Number: 1005240936
Map Created On: March 12, 2022
Projection: GCS WGS 1985
Source: DMTI Spatial Inc, British Columbia Open Data Catalogue
0 112.5 225 450 675 900
Kilometers
Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, NRCan, Parks Canada, Esri, USGS

Map 4:


Map of Routes to Hospitals
Mackenzie
N
Great Bear Lake
Yukon
Mackenzie Mountains
Northwest Territories
Yukon
Legend
Northern Health Care Boundary
Facilities
Incidents
Queen Charlotte Sound
Coast Mountains
Rocky Mo
Vancouver
Seattle
Washington
Portland
Cartographer: Parmvir Grewal
Student Number: 1005240936
Map Created On: April 2, 2022
Projection: GCS WGS 1985
Source: DMTI Spatial Inc, British Columbia Open Data Catalogue
0 112.5 225 450 675 900
Kilometers
Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, NRCan, Parks Canada, Esri, USGS

8. Discussion

The results answer my research question as Table 1 helps show how the northern portion of British Columbia has the least hospitals per land size and how spread out the population is of northern British Columbia compared to other health authorities. This shows that northern British Columbia compared to other health authorities isn't being provided an adequate number of hospitals for their population and land size. Next, Table 2 provides me with the average travel time to the nearest hospital from each health community boundary. From the tables, it can be seen which health community to the hospital takes the longest time and the shortest. These results show how some communities are not receiving adequate health care with hospitals being over an hour away, the distance in meters also shows just how far some of the population must travel to reach their nearest hospital. Some of the ways my results are limited in answering my research question are there is not any census data to go along with my travel time calculations to do a deeper analysis of the populations that is being affected. My results also don't consider public transit travel times which could be a good factor to look at as well. Overall, the results are like other relevant literature I looked at. One of the articles showed how there are a few hospitals that take more than an hour to get to in non-urban areas which match up with some of my results as well (Schuurman, 2006). There are also differences in my results from the relevant literature, for examples one of the literature used different roads files and tools to calculate average travel times. The literature also used census blocks instead of community health boundary points. Other literature also didn't have the same research question, so results varied. Some of the equity and bias concerns found from my results are northern British Columbia is lower income and rural side of British Columbia with differences in

ages, education and geographic location which plays a major role. The data is restricted to download unless logged in with a University of Toronto account also some of the data is hard to come by or is not measured specifically for northern British Columbia. The implications of the information I generated is that although some northern communities do have short driving times to the nearest Hospitals there is still a huge gap where a lot of communities don't. Some communities have over 1hr 30min drive to the nearest hospital which needs to be addressed.

9. Recommendations

Based on the information I found for my research question I would recommend looking at table 2 and at what communities have over 30-60 min plus drives to hospitals. The motivation for my work is hoping that when looking at travel times to the nearest hospital takes some communities over an hour the issues are addressed, and more hospitals are built and strategically placed to help communities who have large travel times to hospitals. For example, for the Peace River North Rural community to drive to its nearest hospital takes over 2 hours which is absurd and needs to be addressed. I'm recommending this to provincial and federal governments to take some action and put some funding towards northern communities of British Columbia at the community level scale. Other research/data/analysis steps I would recommend to improve on the information I generated to more accurately and completely answer my research question would be to get access to more recent data as some of my layers were from 2016. I would also recommend getting a network road layer that takes speed limits, stoplights, stop signs, and terrain into account for more accurate driving times which I was unable to retrieve. Lastly, I would recommend looking at driving times to the nearest hospitals by public transit.

10. Study Limitations

The limitations of the data I used was that some of the data wasn't recent and was from 2016 so there could have been changes in the data since then like a new hospital being built which could change up the results. The data also was hard to find and sometimes needed to be aggregated to the specific geographic area I was looking at. Healthcare (HCR) dataset was the only one I could find that had hospital locations for my study area, but it had other health centers as well which needed to be filtered out. Some limitation to my analysis was that there was no census data connected to the community boundaries that I used to get travel times, which would have strengthened my analysis. Also due to lack of data I couldn't get travel times through public transits which limited my analysis as well because only one mode of transportation was looked at. These limitations affect my results because the results could be more accurate if better data was available. This is why I recommend if better data can be accessed the results and analysis could be improved.

11. Esri ArcGIS Online WebApp link

https://arcg.is/11H9SK0

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